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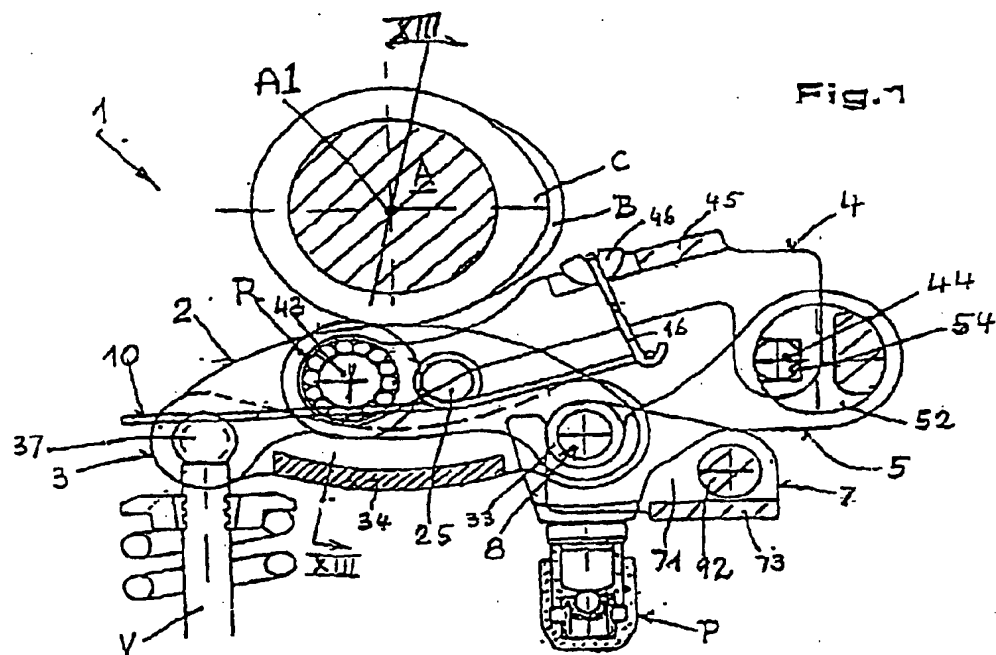
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(54) **Rocker arm device for simultaneous control of valve lift and relative timing in a combustion engine**

(57) A valve control system including a valve actuating camshaft (A), having a high lift cam (B) and a low lift cam (C), and an outer rocker arm (2) engaging the high lift cam, and an inner rocker arm (3) engaging the low lift cam. The ends of the rocker arms adjacent the engine poppet valve (V) are fixed to each other by a connector pin (37). The system includes a latching mechanism

disposed at the ends of the rocker arms opposite the connector pin (37). Latching of the rocker arms is accomplished by a compound pin (8) moved between latched (FIG. 14A) and unlatched (FIG. 14B) conditions in response to movement of an actuator (9). The system also includes a rocker ratio varying device, such that, during operation in the low lift mode, the lift can be gradually increased as the engine speed increases.



**Fig. 1**

## Description

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority, under 35 U.S. C. 119, of earlier-filed Italian Application MI98A002244, filed October 20, 1998.

### STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

### MICROFICHE APPENDIX

[0003] Not Applicable

### BACKGROUND OF THE DISCLOSURE

[0004] The present invention concerns a rocker arm device suitable for optimizing the functioning of internal combustion engines by controlling the opening and the timing of the cylinder valves according to the engine load and its speed.

[0005] For this purpose, it is already known how to use compound rocker arms consisting of two elements as specified in the Italian patent application No. MI97A002067 filed September 11, 1997 in the name of Majo Ceur, and incorporated herein by reference. The first element consists of a rocking body, acting as a third-order lever, hinged at one end to an hydraulic lash adjuster, while the other end controls, by a shoe, the valve stem.

[0006] The second element comprises a lever, at one end of which is pivoted a roller, which receives the thrust of the cam of the distributing shaft (camshaft), while the opposite end of the lever terminates in an eyelet and is hinged to a pin which can turn within a pivot seat fashioned in said eyelet. The pin is torsionally linked to an eccentric support shaft, the rotation of the shaft being able to shift lengthwise the free end of the lever bearing the roller, so as to vary the position of incidence of the end of the lever itself by influencing the length of the arm of the body of the first element and, therefore, the valve lift and, in part, the timing of the latter. Such an arrangement is referred to as a VRRS (variable ratio rocker system).

[0007] With the known device, however, changes in the timing are accomplished only as a result of the particular geometrical shape selected for the cam.

### BRIEF SUMMARY OF THE INVENTION

[0008] The purpose of the invention is to improve the performance of the known device, enabling a subsequent and independent variation of the timing, along with a regulation of the valve lift.

[0009] In the device according to the invention, a pair

of rocker arms is placed one within the other and is able to oscillate jointly or independently, and influence in a controllable manner the travel of the shoe associated with the engine poppet valve, thus controlling the valve lift.

[0010] The two rocker arms are linked together at one end by means of a common transverse pin, acting as a shoe on the head of the poppet valve, while at the other end the rocker arms are traversed by a compound pin controlled by an hydraulic or electrical actuator which can move transverse to the rocker arms, between two positions, enabling the coaxial and simultaneous oscillation of the two rocker arms in unison in one condition, or the independent oscillation of the rocker arms in the other condition.

[0011] For each rocker arm, the distributing shaft (camshaft) is provided with a cam arrangement, specifically, a central cam, acting on the inner rocker arm, which has less eccentricity than the eccentricity of a pair of identical cams, mounted at the sides of said central cam and acting on cheeks or lateral plates of the outer rocker arm to accomplish a larger valve opening and a longer advance.

[0012] The thrust of the central cam is transmitted to a needle roller, mounted at the end of an L-shaped lever, the fulcrum of which can be displaced lengthwise with respect to the axis of the rocker arms by means of an eccentric rotating pin. The pin rotates relative to the end of an auxiliary arm which, at the other end, accommodates the seat for the axis of oscillation of the pair of rocker arms.

[0013] Through the above mentioned auxiliary arm, which rests against a tappet, one can indirectly guarantee the contact of the inner rocker arm with the roller, the L-shaped lever, and the central cam of the distributing shaft, while the contact of the outer rocker arm with the two outer cams is obtained by means of an auxiliary elastic element connected between the L-shaped lever and the shoe.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention will be better understood through the following description, making reference to the enclosed drawings, on which:

FIG. 1 represents an overall view of the device, in lateral elevated view;

FIGS. 2A and 2B show one of the two cheeks or lateral plates comprising the outer rocker arm, in elevated and plan view, respectively;

FIGS. 3A and 3B show the inner rocker arm, in elevated and plan view, respectively;

FIGS. 4A and 4B show the L-shaped lever carrying the roller, in elevated and plan view, respectively;

FIGS. 5A and 5B show, in elevated and plan view respectively, the auxiliary spring which keeps the outer rocker arm in contact with the cams;

FIG. 6 shows a brace for the auxiliary spring of FIG. 5;

FIGS. 7A and 7B show, respectively in lateral elevated and plan view, the auxiliary arm which guides the pin for the oscillation of the rocker arms at one end, and at the other end forms an eccentric seat for the pivot pin of the L-shaped lever of FIG. 4;

FIG. 8 shows the compound pin for controlling the latching of the rocker arms;

FIG. 9 shows the locking pin, on the cheeks of the outer rocker arm, for the auxiliary spring represented in FIG. 5;

FIG. 10 shows the common shaft of the rocker arms, forming the shoe of the device;

FIG. 11 shows, in median lengthwise section, the fork for shifting the actuator to modify the timing;

FIG. 12 shows, in plan view, the fork for shifting the actuator to modify the timing;

FIG. 13 shows the device of FIG. 1, sectioned along line XIII-XIII;

FIG. 14A shows, somewhat schematically, in top plan view, a feature of the device of the invention in order to illustrate the position of the actuator for the mutual linking of the inner and outer rocker arm;

FIG. 14B shows, somewhat schematically, the position of the actuator for disconnecting the inner rocker arm from the outer one.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] Referring now to the drawings, which are not intended to limit the invention, FIG. 1 illustrates a valve control system, made in accordance with the present invention, for use in controlling the engine poppet valves of an internal combustion engine. The valve control system generally includes an inner rocker arm 2, an outer rocker arm 3, an L-shaped lever 4, and an auxiliary element 5. The system further includes a fork element 7, a compound pin 8, an actuator 9, an elastic element 10, and a connector pin 37. Each of the above-mentioned items will be described in greater detail hereinafter.

[0016] The inner rocker arm 3 (see FIG. 3) is formed by two parallel lateral walls 35, 35', joined together by a central bottom piece 34, an upper profile 36 of the walls 35, 35' being concave. The inner rocker arm 3 has, at one of its ends, a seat (bore) 31 for the transverse connector pin 37, the pin 37 comprising the contact surface with the valve stem V. At the other end of the inner rocker arm 3 is an opening 32 to accommodate a bushing 33, defining a bore 38, within which the parts of the compound pin 8 can easily slide, the function of which shall be described afterwards.

[0017] The outer rocker arm 2 is formed by two cheeks or plates 2', 2" (see FIG. 2), the outside of each of which is placed against the lateral walls 35, 35' of the inner rocker arm 3 (see also FIG. 14A). The plates 2', 2" have upper surfaces 26 which are convex, the two

plates 2', 2" of the outer rocker arm 2 having at one of their ends a seat (bore) 21 for the connector pin 37 of the two rocker arms and, having at the other end, a seat (bore) 22 for the compound pin 8.

[0018] The L-shaped lever, designated as 4 (see FIG. 4), has a cross-section of an inverted U, with two walls 40, 40' joined together by an upper plate 45 from which is made, such as by a punch operation, a bracket 46 and a seat 47 for purposes to be indicated. The L-shaped lever 4 has, at the end of a longer branch 48, a seat (bore) 42 for an axle 43 of a roller (cam engagement member) R and, at the end of a shorter branch, a seat (bore) 41 for an oscillating pin 44. The branch 48 has a lower cylindrical end 49 supported against the concave surfaces 36 of the inner rocker arm 3.

[0019] The auxiliary element 5 is mounted in alignment with the lengthwise center line of the inner rocker arm 3 (see FIG. 14A), and comprises at one end a circular hole 51 which supports a pin 52 (shown only in FIG. 1), the pin 52 being better understood by reference to the above-incorporated Italian application. The pin 52 has an eccentric notch 54, within which is guided an oscillating pin 44 of the above-described L-shaped lever 4. The auxiliary element 5 terminates at the opposite end with a semicircular seat 55, which is bounded by an outside shoulder 57, for holding the bushing 33 of the compound oscillating pin 8 of the two rocker arms. The auxiliary element 5 has at the bottom, with respect to the seat 55, a support surface 56 against a tappet (hydraulic lash adjuster) P. The semicircular seat 55 has a diameter equal to that of the bushing 33, so that the bushing 33 can be disposed in the bore 32 of the inner rocker arm 3;

[0020] The elastic element 10 (see FIGS. 5A, 5B), is formed by a single spring steel wire 11, having an essentially rectangular shape in plan view, with a width L' greater than the width L of the assembled rocker arms (FIG. 14A). As a result, the element 10 can be wedged on the outside of the cheeks 2', 2", being joined by its oyolets 15 to the bolts 25 (FIG. 9) which are secured to the cheeks 2' and 2", (see FIG. 2A). The elastic element 10 has at one end a continuous segment 12, while at the opposite end it has two free branches 14, 14', bent inwardly to rest against the top of the connector pin 37 of the two rocker arms. The elastic element 10 is elastically held in a state of tension by a U-clip 16 (see FIG. 6) with ends bent in hook shape 17, able to be connected to the segment 12 of the elastic element 10, the cross piece 18 of the clip 16 being capable of insertion in the seat 47 of the L-shaped lever 4. The element 10 and the clip 16 are included for the purpose of maintaining the cheeks 2', 2" of the outer rocker arm 2 in contact with the pair of cams B (see FIG. 13).

[0021] The compound pin 8 (see FIG. 8), comprises three generally cylindrical parts 81, 82, 83, of which the shortest part 81 has a length equal to the transverse thickness of the plate 2" of the outer rocker arm 2 (see FIG. 14B). The part 82 has a length equal to the width

of the inner rocker arm 3 and of the bushing 33 (again see FIG. 14B), while the part 83 has a length around 50% greater than that of the shortest part 81. The pin parts 81, 82, and 83 have a diameter slightly less than that of the seats 22 of the cheeks 2' and 2" and slightly less than the internal diameter of the bore 38 of the bushing 33, which can be mounted within the seat 32 of the inner rocker arm 3.

**[0022]** The connector pin 37 (see FIG. 10) is secured in the aligned openings 31 of the inner rocker arm 3 and in the openings 21 of the cheeks 2' and 2", which are placed against the walls 35 and 35' of the inner rocker arm 3. In accordance with an important feature of the present invention, the pin 37 connects the two rocker arms 2 and 3 for either a common action ("latched") or a separate action ("unlatched") of these arms on the engine poppet valve V. The connector pin 37 is orientable within the aligned holes 31 and 21 so that a flattened middle part 38V always rests against the head of the poppet valve V.

**[0023]** The fork element 7 (see FIGS. 11 and 12) has two bent branches 71, 71' with an internal spacing 72 slightly greater than the total of the lengths of the three cylindrical parts 81, 82, 83 of the compound pin 8, one next to the other. The branches 71, 71' form walls 71a and 71a' that approach each other and are joined together by means of a lower connection bridge 73, forming with them a U-shaped body 74, the branches 71a and 71a' having corresponding holes 75 for insertion of a shaft 92 of the actuator 9.

**[0024]** The actuator 9 (see FIG. 14A) is operated by an oil-dynamic (hydraulic) piston 91 or, alternatively, by electrical means, or any other suitable means, the particular design of the actuator 9 not comprising an essential feature of the invention. The piston 9 has a shaft (output) 92 which is guided by the piston 91, the piston 91 being disposed within a cylinder 95 which may preferably be designed for the possibility of a fairly short translation (piston stroke). The fork 7 is disposed on the shaft 92 in a position normally abutting against a locking washer 93, as a result of the force of a biasing spring 94 acting against the branch 71a' of the fork 7 and seated against the washer 96, which is fixed relative to the shaft 92.

**[0025]** Supplementing the above description with regard to the actuator 9 and the mounting of its components, FIG. 13 shows the positioning of the distributing shaft A and of the respective cams B and C with regard to the functioning of the device according to the invention. The central cam C acts on the roller R arranged at the end of the L-shaped lever 4. The impulse of the cam C is transmitted to the axle 43 of the roller and to the body of the lever 4, which rests by its cylindrical end 49 against the concave surfaces 36 of the inner rocker arm 3.

**[0026]** Accordingly, the cam C acts on the inner rocker arm 3 ("low lift"), while the outer rocker arm 2 comprising the cheeks 2', 2" is actuated by the outside cams B di-

rectly against the convex surfaces 26 of the cheeks themselves. When the cams B, having a greater eccentricity, press against the outer rocker arm 2, connected to the inner rocker arm 3 by the connector pin 37, the cam C is thereby rendered ineffective.

**[0027]** The action of the cams B, with greater eccentricity, therefore produces a greater valve lift of the engine poppet valve V ("high lift"), an earlier opening and a later closing, and this in response to higher engine speed. When the inner rocker arm 3 is being controlled by the cam C, to accomplish low lift, the specific amount of lift can be varied as a function of a vehicle or engine parameter, such as speed. This further variation of lift is controlled by means of the actuator 9, as shall be explained below.

**[0028]** FIGS. 14A and 14B illustrate the action of the actuator 9. At relatively higher engine speeds, and as shown in FIG. 14A, the fork 7, by means of the piston 91, is displaced along the direction of the arrow F1 and the branch 71' abuts against the cheek 2' of the outer rocker arm 2. The part 83 of the pin 8, securing the cheek 2', enters the bushing 33, pushing the central part 82 of the pin 8 through it, along an axis A2, and the part 81 of same secures the cheek 2", so that both the rocker arms are joined ("latched"). The assemblage of the two rocker arms is thus controlled only by the outside cams B ("high lift") and the cam C is ineffective. At relatively lower engine speeds, the piston 91 is retracted, along its axis A3 (see FIG. 14A) as in FIG. 14B, pulling the fork 7 in the direction of arrow F2, and therefore only the inner rocker arm 3 operates, because the two cheeks 2', 2" of the outer rocker arm 2 are idle on the compound pin 8. In this fashion, the inner rocker arm 3 is unlatched and can oscillate about the bushing 33, which is always supported by the semicircular seat 55 of the auxiliary element 5, the tip 57 of whose outside shoulder is shown in FIG. 14A.

**[0029]** In accordance with an important aspect of the invention, the valve control system illustrated and described herein provides both dual lift capability, in response to the rocker arms being either latched (FIG. 14A) or unlatched (FIG. 14B), and also VRRS capability, in response to rotation of the eccentric pin 52. More specifically, and as merely one example of the use of the present invention, whenever the system is operating in the low lift mode of FIG. 14B, the pin 52 is initially in the position shown in FIG. 1. The described position of the pin 52 corresponds to a minimum speed condition, in which the roller R is disposed at the far left end of its travel in FIG. 1, which represents the minimum lift of the poppet valve V. As the engine speed gradually increases, the pin 52 rotates clockwise from the position shown in FIG. 1, thus moving the L-shaped lever 4 to the right in FIG. 1, and also moving the roller R to the right. As the roller R moves to the right in FIG. 1, the effective point of contact of the low lift cam C and the inner rocker arm 3 moves to the right, gradually increasing the lift, even while in the low lift mode. Once the engine speed

reaches a certain, predetermined level, the actuator 9 moves to the latched condition of FIG. 14A, and thereafter, the system operates in the high lift mode, with the amount of lift remaining constant, during which the position of the lever 4 and roller R is irrelevant to the amount of lift.

[0030] It should be noted that the present invention is illustrated in the drawings as comprising a series of parts which, in some cases, could probably be combined with each other, or formed integrally with the cylinder head, or in some other manner redesigned to reduce the total number of parts. However, the objective of showing the version of the present invention being shown herein is partly to illustrate the various functions which should preferably be performed by various parts of the entire valve control assembly, and those skilled in the art will understand that the invention is not limited to the particular parts being separate as shown.

[0031] The invention has been described in great detail in the foregoing specification, and it is believed that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims.

## Claims

1. A valve control system for an internal combustion engine of the type including a cylinder head, an engine poppet valve (V), and a valve actuating camshaft (A) defining a cam axis (A1) having a first cam (B) and a second cam (C); said valve control system comprising a first rocker arm (2) disposed for operable engagement with said first cam (B); a second rocker arm (3) disposed for operable engagement with said second cam (C); and means having a first condition (FIG. 14A) for selectively interconnecting said first (2) and second (3) rocker arms for pivotal movement in unison in response to a force applied by said first cam (B) to said first rocker arm (2); said means for selectively interconnecting having a second condition (FIG. 14B) in which said first (2) and second rocker arms have pivotal movement relative to each other; characterized by:

(a) each of said first (2) and said second (3) rocker arms having a valve end (21, 31) disposed adjacent said engine poppet valve (V);  
 (b) a connector (37) operably associated with said valve ends (21, 31) of said rocker arms (2, 3) whereby the only relative movement permitted between said first (2) and second (3) rocker arms is said relative pivotal movement said movement being about said connector (37), said relative pivotal movement occurring only

when said means for selectively interconnecting said rocker arms (2, 3) is in said second condition (FIG. 14B); and

(c) one of said second rocker arm (3) and said connector (37) being configured for engagement with said engine poppet valve (V).

2. A valve control system as claimed in claim 1, characterized by each of said first (2) and second (3) rocker arms having a latching end (22, 32) disposed at the axially opposite end from said valve ends (21, 31), said means for selectively interconnecting said rocker arms (2, 3) being operably associated with said latching ends (22, 32) of said rocker arms (2, 3).
3. A valve control system as claimed in claim 2, characterized by said latching end of said first rocker arm (2) defining a first latch bore (22) and said latching end of said second rocker arm (3) defining a second latch bore (38), said latch bores (22, 38) being coaxial with each other when said means for selectively interconnecting said rocker arms (2, 3) is in said first condition (FIG. 14A), said latch bores (22, 38) defining an axis (A2) substantially parallel to said cam axis (A1).
4. A valve control system as claimed in claim 3, characterized by said means for selectively interconnecting said rocker arms (2, 3) comprises a latch member (82) axially moveable within said first (22) and second (38) latch bores between said first condition (FIG. 14A) in which said latch member (82) is disposed within both of said latch bores (22, 38) and said second condition (FIG. 14B) in which said latch member (82) is disposed within only said second latch bore (38).
5. A valve control system as claimed in claim 4, characterized by said means for selectively interconnecting said rocker arms (2, 3) includes an actuator assembly (9) defining an axis (A3), said axis (A3) being substantially parallel to said cam axis (A1), said actuator assembly (9) including an output member (92) axially moveable along said axis (A3) between first (FIG. 14A) and second (FIG. 14B), to move said latch member (82) between said first condition (FIG. 14A) and said second condition (FIG. 14B), respectively.
6. A valve control system as claimed in claim 4, characterized by said latch member (82) being wholly disposed within said latching bores (22, 38), as said latch member (82) moves between said first condition (FIG. 14A) and said second condition (FIG. 14B), whereby said latch member (82) is not exposed outside of said rocker arms (2, 3).

7. A valve control system for an internal combustion engine of the type including a cylinder head, an engine poppet valve (V), and a valve actuating cam-shaft (A) defining a cam axis (A1) having a first cam (B) and a second cam (C); said valve control system comprising a first rocker arm (2) disposed for operable engagement with said first cam (B); a second rocker arm (3) disposed for operable engagement with said second cam (3); and means having a first condition (FIG. 14A) for selectively interconnecting said first (2) and second (3) rocker arms for pivotal movement in unison in response to a force applied by said first cam (B) to said first rocker arm (2); said means for selectively interconnecting having a second condition (FIG. 14B) in which said first (2) and second rocker arms have pivotal movement relative to each other; characterized by:

(a) each of said first (2) and said second (3) rocker arms having a valve end (21, 31) disposed adjacent said engine poppet valve (V);  
(b) a connector (37) operably associated with said valve ends (21, 31) of said rocker arms (2, 3) whereby the only relative movement permitted between said first (2) and second (3) rocker arms is said relative pivotal movement, said movement being about said connector (37); and  
(c) a cam engagement member (R) in operable engagement with said second cam (C) and with said second rocker arm (3), and means (4,44,52) operable to vary the location of said cam engagement member (R), and the resulting valve lift, while said means for selectively interconnecting is in said second condition (FIG. 14B).

8. A valve control system as claimed in claim 7, characterized by each of said first (2) and second (3) rocker arms having a latching end (22, 32) disposed at the axially opposite end from said valve ends (21, 31), said means for selectively interconnecting said rocker arms (2, 3) being operably associated with said latching ends (22, 32) of said rocker arms (2, 3), and said cam engagement member (R) being disposed intermediate said valve ends and said latching ends.
9. A valve control system as claimed in claim 1, characterized by said second rocker arm (3) defining an upper concave surface (36), and said cam engagement member comprising a roller (R) in engagement with both said second cam (C) and said concave surface (36).

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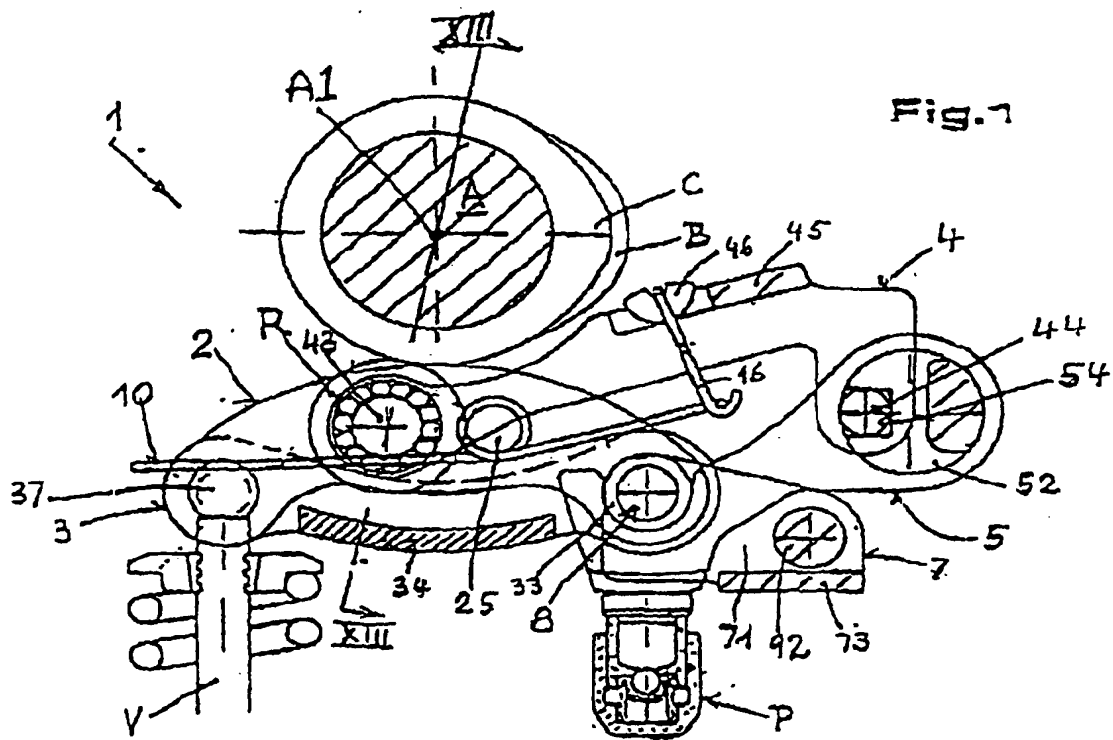


Fig. 1

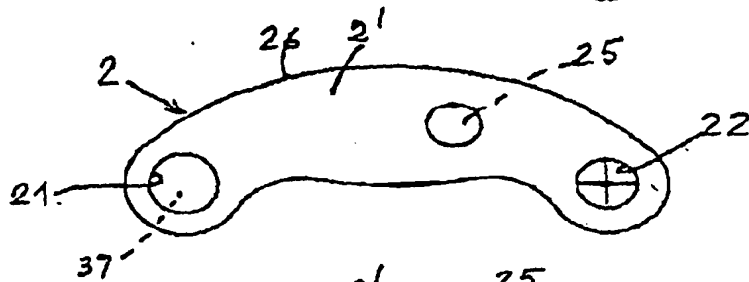


Fig. 2 A

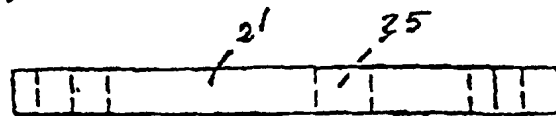


Fig. 2 B

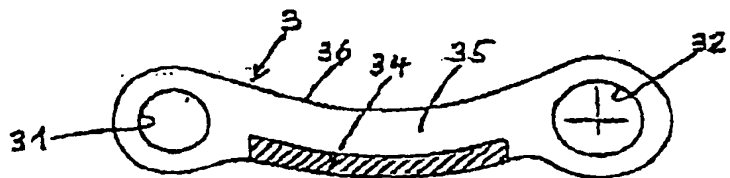


Fig. 3 A

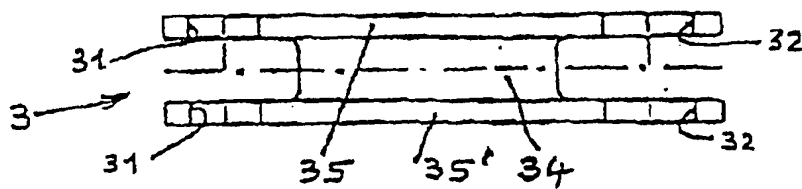


Fig. 3 B

Fig. 4A

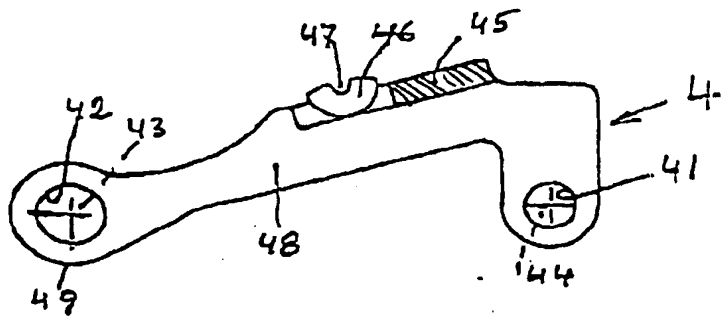


Fig. 4B

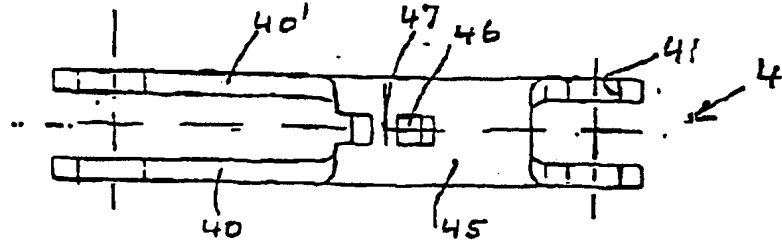


Fig. 6

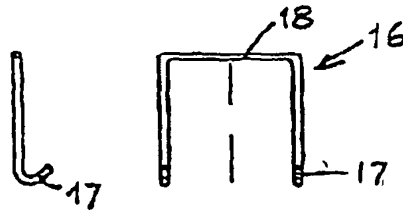
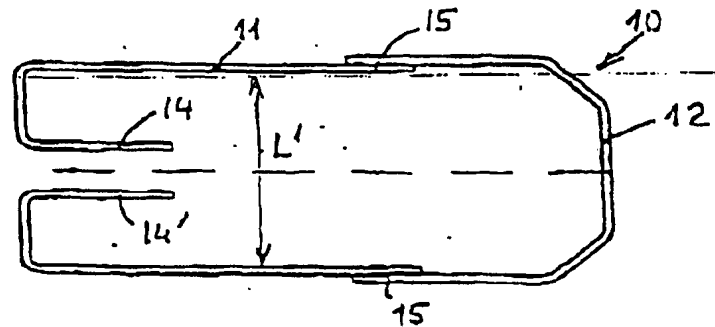


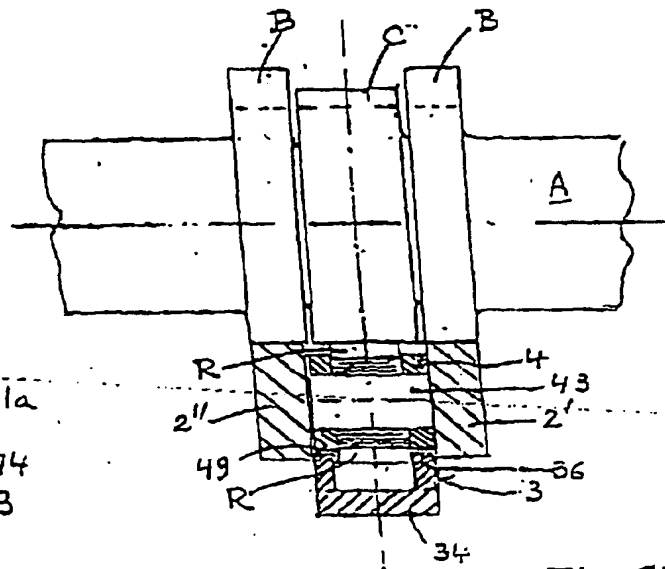
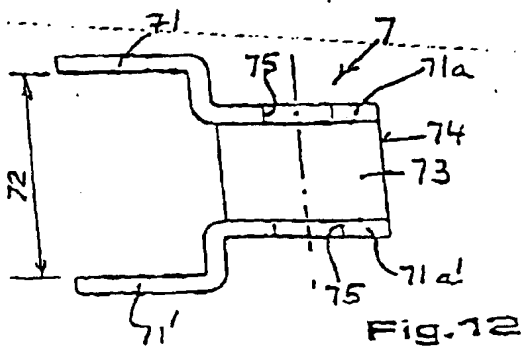
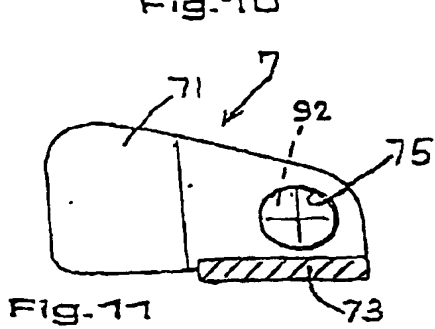
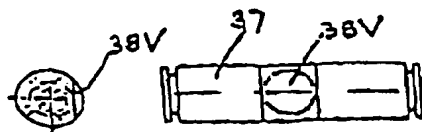
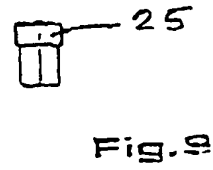
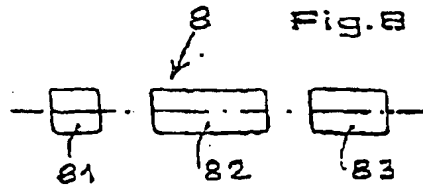
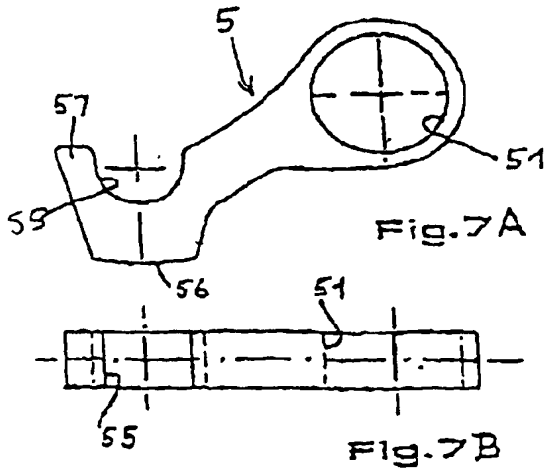
Fig. 5A



Fig. 5B







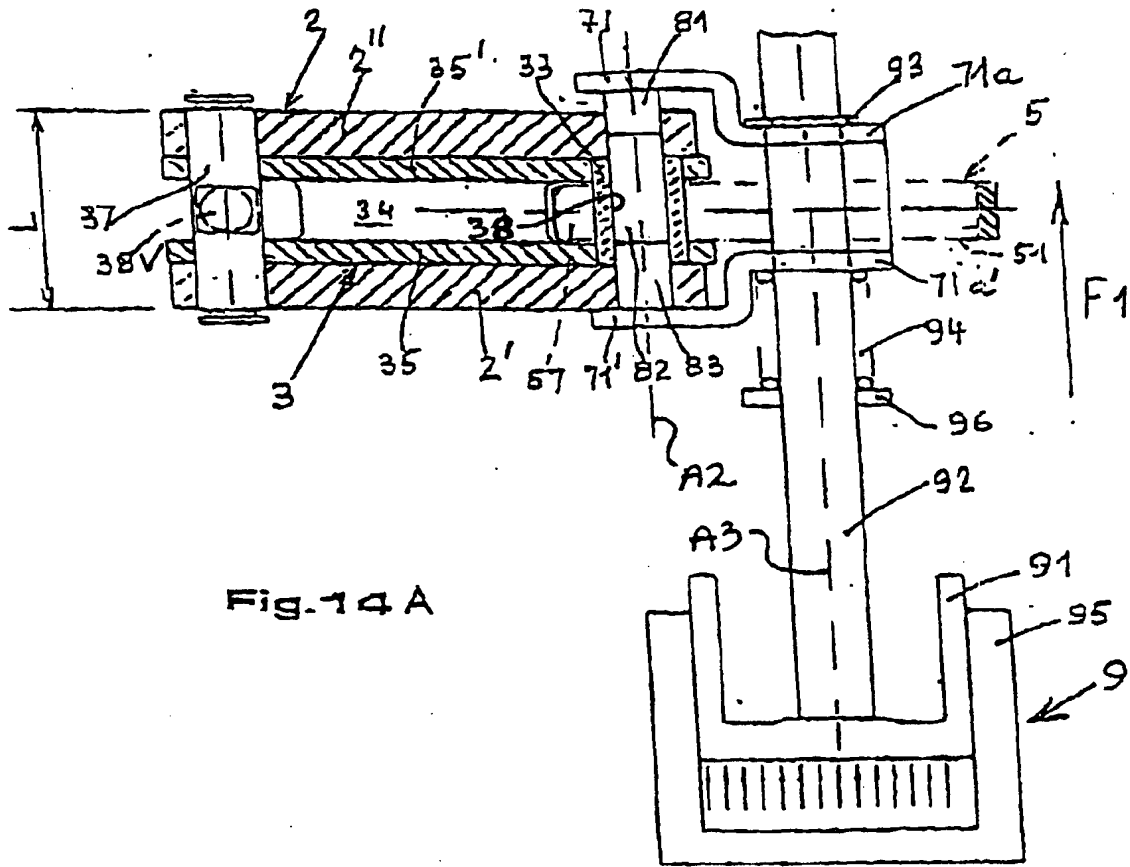


Fig. 14 A

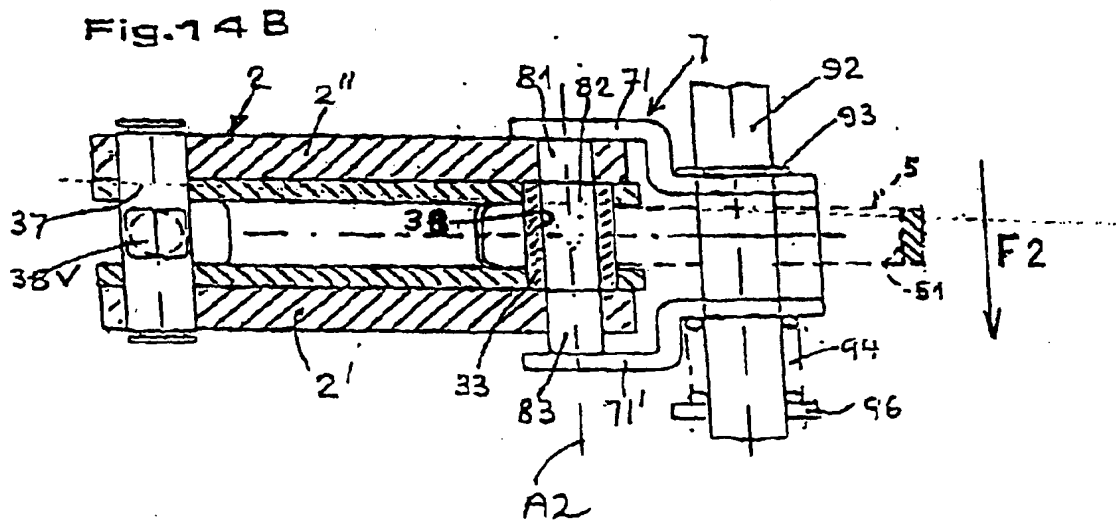


Fig. 14 B